China's Prospects as an Innovative Country:

An Industrial Economics Perspective

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Abstract
The recently announced Independent Innovation Strategy (IIS) signifies the climax of China's technology catch-up effort during the past 30 years. This paper investigates the efficacy of, and prospects for this effort by reviewing comments from the relevant literature, by conducting a theoretical analysis based on industrial economics and by testing hypotheses with the latest empirical evidence. Our results suggest a bleak prospect for IIS if the Chinese government retains its excessive administrative protection of state-owned enterprises, and a long struggle ahead for China to finally push further into the technology frontier.

JEL Codes: L12, O38, P31
Keywords: state monopoly, R&D, independent innovation, state-owned enterprise

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List of Acronyms and Abbreviations

CP	Complementary Policies
CPC	the Communist Party of China
DEs	Domestic Enterprises
FFs	Foreign Firms
FFEs	Foreign-funded Enterprises
GERD	Gross Expenditure on R&D
HMT	Hong Kong, Macao and Taiwan
HTDZs	High-Tech Development Zones
IIS	Independent Innovation Strategy
LMEs	Large- and Medium-sized Enterprises
MNCs	Multi-National Corporations
MOF	Ministry of Finance
NIS	National Innovation System
NBS	National Bureau of Statistics
R&D	Research and Development
SASAC	the State-owned Assets Supervision and Administration Commission
S&T	Science and Technology
SOEs	State-owned Enterprises
STS	China Science and Technology Statistics

The Master said:
"At fifteen, I had my mind bent on learning.
At thirty, I stood firm.
At forty, I had no doubts.
At fifty, I knew the decrees of Heaven.
…"

Confucius, *The Confucian Analects*, 500 BC

1. Introduction

The year 2008 witnesses the 30th anniversary of China's reform and open-door policy, which at first dragged the country back from the brink of economic collapse, and then amazingly guided this largest developing economy to achieve an unprecedented growth record. According to Confucian wisdom, the age of 30 symbolizes the crucial point when a person establishes a career path. Therefore, at this historic moment, people are naturally eager to know about China's blueprint for the future, and more importantly, its feasibility.

The construction of an innovative country is no doubt a fundamental aspect of this blueprint. China has long been criticized for being trapped in its comparative advantage, by simply making profit in the final stages of production (assembling/processing) that are labor intensive, while the upstream, capital-intensive stages of production (critical semi-finished products and components) are imported or imitated. Observers believe that the lack of technological preeminence would soon constrain China's next phase toward moderate prosperity—the achievement of a per capita income level of $10,000, where innovation capability is more important to sustain the momentum of growth. In response, the Chinese government has significantly increased its investment in the science and technology (S&T) domain ever since the mid 1990s and urged domestic enterprises to enlarge their research and development (R&D) outlays to enhance their innovation capability. It even promulgated a "National Guidelines on a Medium- and Long-term Program for Science and Technology Development 2006-2020" (hereafter S&T Guideline) to substantiate the central government's determination of reshaping China into an innovative country through its "Independent Innovation Strategy" (IIS)[2] (*Zizhu Chuangxin Zhanlue*)

Surprisingly, there is very little international literature to assess the foregoing policies. This paper is a first attempt to summarize the relevant literatures and to briefly analyze their contributions and deficiencies. To overcome those deficiencies, we further outline a conceptual model to systematically reveal the negative influences of China's state monopoly on its market structure and innovation performance, indicating a poor prospect for IIS. Beyond that, by re-examining the data sets employed in previous studies and supplementing them with new empirical material

[2] Alternative English translations for the Chinese are "Self-Innovation Strategy" or "Self-reliance Innovation Strategy"

available, this research will identify the problems that have led to an overoptimistic estimation of China's S&T takeoff process and will uncover solid evidence that strengthens its theoretical prediction.

The remainder of this paper is organized as follows: Section 2, on "Debates", presents a review of the controversies that have arisen around China's government mandated technology catch-up attempt. Section 3, on the "Anatomy of the catch-up attempt", reinterprets the previous debate in terms of a market structure analysis, where we unveil the inertia among state-owned enterprises (SOEs) toward innovation, and their hostility to horizontal and vertical innovation flows. In Section 4, on "Empirical evidence", together with a discussion of relevant data sets, we revise the expectations of the outcome of China's pledge to become a leading innovative nation. Section 5 concludes the paper.

2. Debates

2.1 Prefatory Remarks

Historically, the Chinese people launched two remarkable attempts to catch up with the global technology frontier after the Opium War in 1840, both of which lasted three decades, or so and ended up as miserable failures. First, during the 30-year period 1865-1894, the Qing dynasty conducted the "Foreign Affair Movement" (*Yangwu yundong*) which widely established publicly financed schools and arsenals that aimed to modernize the late imperial China. However, an unexpected defeat in the Sino-Japanese War (1894-1895) terminated this attempt, only leaving behind blame for its failure due to its over-reliance on an irredeemably corrupt and inefficient government (Elman, 2003).

The government did change after the Communist Party of China (CPC) took over the country in 1949, ceasing its constant state of war throughout the first half of the 20th century, and started to pursue a heavy-industry-oriented development strategy. The new central government expected that the Soviet model could rapidly lead the country to regain its economic and technology power, but, ironically, after the Great Leap Forward in 1958 and the Cultural Revolution from 1966-1976, economic development stagnated and the technology gap between China and the advanced countries clearly increased as a result of the advent of another worldwide technical revolution at the same time. This irrational command economy pursued over 27 years (1952-1978) ultimately resulted in the outcome that China became one of the poorest countries in the world by 1978, with a per capita GDP of $148, lower than contemporary Pakistan's $260, India's $248, let alone the developed countries' average of $10,000 (OECD, 2002).

In the last three decades, in contrast, China has achieved stunning economic growth in its third attempt to catch up—the Reform and Opening Up, where "Reform" mainly stands for moving away from a centrally planned economy to a market economy and "Opening Up" represents the transformation from a closed or semi-closed nation to a fully opened one (S. Hu, 2008). Between 1978 and 2006, China maintained an annual nominal GDP growth rate of 9.7 percent, enlarging its economic magnitude for more than 13 times. In 2007, the overall size of the economy ranked fourth in the world, and the volumes of import and export, $2.17 trillion, made China the third-largest trading nation. In particular, the persistent execution of a national technology-enhancing strategy during the last two decades: namely, "trading market share for technology"[3](Cheng, 2008; Liu, 2002; Ran et al, 2007), has appeared to significantly improve China's industrial technology level: an examination of China's export composition shows a large shift from primary products to manufactured goods since the 1980s, and an increased share of relatively capital- and technology- intensive products – mainly machinery and transport equipment (SITC 7) after the mid-1990s (OECD, 2002). Given this sustained momentum, nearly 150 years after the "Foreign Affair Movement", the Chinese people's perseverance in the pursuit of advanced technology finally seems to have paid off.

However, at this point the China's Miracle becomes ambiguous, and a controversial story thus unfolds.

2.2 "Phantom menace" versus "S&T takeoff" in China

Gilboy's criticism (2004) of the fictitious explosion of China's technology and innovation capability is probably the most representative among similar studies (OECD, 2002; Parker, 1995), because of its uniquely structural and institutional analysis of China's industrial restructuring process, combined with pertinent cases, observations and informative data. By stressing that foreign firms are still claiming the lion's share of China's industrial exports, while its domestic technology leader --the state-owned enterprises (SOEs)-- is severely addicted to imported technologies, Gilboy depicted the current Chinese industrial structure as being composed of inefficient yet powerful SOEs, increasingly dominant foreign firms, and a private sector that is unable to compete with others on equal terms. In this regard, it is unwarranted to take China's sudden rise in global trade, particularly in the export of technology and industrial goods, as a realistic threat to the preeminence of industrialized countries. In addition, from an institutional perspective, Gilboy has generalized China's "industrial strategic culture", which is distorted by its unreformed political system, as an encouragement to seek short-term profit, local autonomy, and excessive diversification. This "culture" tends to chronically jeopardize networking efforts among firms, industries and research institutes, to deny investment in long-term technology development and diffusion, and to indulge inefficiency and technological dependency with local protectionism and particularism, which acting altogether will continue to suppress the formation of a productive national innovation system (NIS).

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[3] The set of policies that introduce Multi-National Corporations (MNCs) to transfer their advanced technology to China, e.g. transferring their latest product or latest technology to MNCs' joint-ventures in China, setting up Research and Development (R&D) centers in China. As a reward, MNCs are accordingly issued with their market entry permissions.

Just like a fuse, Gilboy's paper and its overlooked predecessors soon ignited a nation wide explosion of, hitherto inhibited, reflections on the foregoing technology-enhancing strategy in China (Gao et al, 2007; Lu, 2006). As a response to the outpouring of criticism on the technology innovation performance of domestic industries, on the one hand, the Chinese government tried to advertise *Huwei*, *Haier* and *Bao Steel*, some exceptional domestic enterprises which appeared to be innovative, as examples to counteract the fury; and, on the other hand, surprisingly promptly, the State Council issued the S&T Guideline in February 2006. Along with more innovation assessment indicators such as patents and the amount of international academic publications, the Chinese government mandated that, in 15 years, China's R&D expenditure in GDP will reach 2.5 percent; science and technology progress will contribute at least 60 percent to the country's development; and, meanwhile, the country's reliance on foreign technology will decline to 30 percent and below (Zhu, 2006). Shortly afterwards, this guideline evolved into a new alternative technology-enhancing strategy: namely, the IIS, which was first referred to in China's "11th Five-Year Plan", announced in October 2006 (Pan, 2006), and then reaffirmed by the CPC's "Scientific Outlook on Development" promulgated one year later (J. Hu, 2007). These grass-rooted agreements to Gilboy's criticism together with a series of immediate top-down policy reactions reflected the social consensus that, despite a nearly double digit GDP growth rate, China's international status in terms of innovation capability had barely improved.

On the contrary, Jefferson (2005) argued that Gilboy's estimation of China's inferiority in innovation capability was based on biased observations. For instance, over stressing the difference in performance between Chinese enterprises and foreign-funded enterprises (FFEs)[4] in high-tech products exports tends to ignore the more subtle story of China's technological transformation, where more labor-using and capital- and energy-saving innovations have been produced. Further, Gilboy's data also underestimated the Chinese enterprises' R&D efforts[5]. Apart from these criticisms, Jefferson opposed Gilboy's assertion that China's rise in technological innovation was just a "phantom menace" with reference to two additional sources: first, the national R&D intensity (the ratio of R&D expenditure as a percentage of GDP) of China had rapidly climbed to 1.3 percent in 2003, substantially greater than what would be expected given the country's level of per capita income; second, the preceding surge in China's R&D intensity had resulted from the boom in enterprise-financed R&D instead of government funding, indicating a more market-oriented and commercialized innovation structure. Accordingly, his conclusion is rather that R&D has become extensively and deeply embedded in China's enterprise system, and has thus enabled the country to experience S&T takeoff.

The appearance of another OECD report centered on international comparisons based on a set of science, technology and innovation indicators (OECD, 2006), also echoes Jefferson's opinion. By admitting that, between 1995 and 2004, China's R&D

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[4] FFE includes both foreign firms (FFs) and overseas investment from Hong Kong, Macao and Taiwan (HMT).

[5] Jefferson's large- and medium-sized industrial enterprises (LMEs) data set (1995-2001) revealed that China's domestic LMEs' R&D intensity (R&D expenditure as a percentage of value added) had reached 3.3 percent, instead of the merely 1 percent reported by Gilboy.

spending has quintupled in real terms and ranks right behind the U.S., the EU and Japan, the report named China as one of "the most dynamic elements of the global innovation network"(p. 16). What is more, the report provides more statistics to strengthen the potential of China in innovation, e.g. the number of researchers in the country also increased by 77 percent between 1995 and 2004, ranking second worldwide in terms of human resource input to R&D. Meanwhile, the Chinese government's S&T Guideline was especially highlighted and welcomed as a promising means of ensuring both a degree of continuity in government policy and relevance to a changing innovation environment.

2.3 A Critical Review of the Controversy

Gilboy (2004) insisted that developing technology is a difficult and uncertain process, where neither large capital investment nor a significant stock of existing science and engineering capability can guarantee success. Therefore, the investment issue only matters when assuming "ceteris paribus". Otherwise, investment could be misplaced to disguise more significant deficiencies in a certain innovation system, or to crowd out those more effective solutions but undesirable to the authorities.

This argument appears to be a fatal yet overlooked attack on his opponents: in Jefferson's (2005) paper, S&T takeoff was defined as "an abrupt increase in a country's ratio of research and development spending to GDP from less than one percent to more than two percent" (p.44). And this definition can be traced back to the situation that the seven largest and richest economies in the world all experienced such a remarkable acceleration of R&D intensity on average within the span of a single decade. By measuring China's outstanding R&D intensity growth from 1996-2003 against this criteria, especially combined with another discovery that enterprise-financed R&D accounted for the major part of the increase above, Jefferson saw China in the middle of its S&T takeoff. Unfortunately, huge varieties in differences and gaps still exist between China and the OECD countries[6]in terms of per capita income and educational level, industrial structure, institutions, history and culture, which simply mean that the "*ceteris paribus*" condition no longer holds. Therefore, the attempt to assess a country's creativity by a unidimensional investment criterion is apparently inappropriate. In addition, even within OECD countries, economic history studies have suggested that, rather than R&D intensity growth, the establishment of a social payoff structure favoring innovation and entrepreneurial activities, i.e. the rule of law, the protection of personal property and intellectual property and the antitrust legislation, was the main contribution to their leading position in technology progress (Baumol, 1990, 1993; Landes, 2006; Olson, 1982). Neither was there significant causality identified between R&D investment and innovation capacity among comparable countries (OECD, 2007). As a consequence, policy recommendations that partially emphasize the efficacy of R&D intensity growth as an indicator of technological success, particularly those for developing

[6] The seven countries Jefferson analyzed: namely, the US, Japan, German, the UK, France, Italy, and S. Korea, are all OECD members.

countries like China, are weakly grounded.

Gilboy regarded China's unreformed political system as its Achilles' heel for proposed catch-up efforts. This handicap had two aspects: first, a government-mandated monopoly for SOEs in selected industries has continually spoiled these enterprises. CEOs in SOEs without the pressure of market competition thus prefer to forgo independent innovation which contains more risks in terms of the fulfillment of their imposed profit and tax turnover objectives. Second, the CPC's control over all aspects of organized life leaves few opportunities for firms to work together for their legitimate common interests. This structure drives business leaders to focus on building relationships through CPC officials and on vertical, bureaucratic relationships instead of independent social organization and horizontal networking, which is extremely hostile to innovation because of its potential destructive effect on vested interests. Therefore, without structural political reforms, China's ability to indigenize, develop, and diffuse technology will remain limited.

Suspicions of Gilboy's conclusion, however, come along with China's reform progress in associated fields after 2003, the year after which all Gilboy's empirics had been sourced. First of all, a new government organ: namely, the State-owned Assets Supervision and Administration Commission (SASAC), was founded in April 2003 to cut direct interference from the government to SOEs. Later, in October of the same year, the central government further called for "mixed ownership" of SOEs, allowing more private investment—and presumably a more entrepreneurial spirit—in them[7] (Fewsmith, 2004). Meanwhile, obliged by SASAC, the central SOEs' R&D investment as a percentage of their sales revenue increased to 36 percent annually after 2003, and their senior managers' performance was required to be assessed additionally with a new index of "science and technology investment" after 2006. Hence, two questions arise: will the reform of SOEs' corporate governance system end their apathy in innovation? And can SASAC successfully wield its power over SOEs to conduct efficient R&D?

In brief, our preceding review discovers that the analysis in the current literatures on China's catch-up efforts in the technology and innovation sphere either suffered from partiality due to dependence on contentious indicators or was lagging behind the most recent policy reforms that happened in the country. Apparently, more robust theory and associated conceptual and operational analysis are required to deepen and update this fascinating debate.

3. Anatomy of the Catch-up Attempt

3.1 Introduction to the Methodology

The promulgation of IIS actually symbolized the advent of a climax in China's latest technology catch-up attempt, where implicit, temporary and topical policy

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[7] See the "Decision of the CPC Central Committee on Several Issues in Perfecting the Socialist Market Economy", approved by the Third Plenary Session of the 16th Central Committee of the CPC.

efforts were finally subjected to state will with explicit, comprehensive strategies (Zheng and Chen, 2006). However, the Chinese government had also learned from previous failures and the experience of industrialized countries that such a state will needs to be carried out consensually by the industrial sectors. Accordingly, though IIS covers a bunch of topics ranging from government procurement to education, and S&T management reform[8], it especially identified enterprises as the key to build an innovative country. Therefore, an analysis of the feasibility of China's technology catch-up attempt can be reasonably framed in the **structure-conduct-performance** methodology of industrial economics, instead of being related to every field indicated in IIS.

According to this view, in brief, market structure determines the behavior of the firms in the market, and the behavior of firms determines the various aspects of market performance (Martin, 1994). Three focal issues of the previous debate, government intervention, R&D investment, and innovative capacity, enter into each of the three aforementioned methodological categories, respectively: the economist's model of perfect competition assumes that a market structure consists of many small buyers and sellers, dealing in a standardized product, under conditions of free and easy entry and complete and perfect knowledge, while the government intervention's intentions and results are always leading to volatility in market **structure**, i.e. changes in the number and size distribution of sellers or buyers, product differentiation and market entry conditions; R&D investments and associated activities, assumed to be **conducted** by firm(s) in a market economy, reflect attempts and efforts to destroy a perfectly competitive market, while seeking technology and product preeminence (monopoly), just like other similar behavior such as collusion in terms of purpose; innovation capacity typically represents the situation of the firm(s) in progressiveness or dynamic efficiency, and directly determines its (their) other performance indicators such as profitability and efficiency, and thus falls into the **performance** category.

3.2 A Conceptual Exploratory Model for Innovation

Baumol's work (Baumol, 2002a, 2002b, 2004) ranks among the most well-known applications of the preceding analytical framework, albeit in an implicit sense, in its attempting to answer one of the most perplexing issues of our time—whence innovation? During his exploration of the modeling of the unprecedented growth and innovation performance of the free-market economies, Baumol suggested that what was missing in all other economies is the pressure to innovate, including active dissemination and promotion of usage. In other words, although markets of substantial importance exist in virtually every economy of the world and have existed throughout recorded history, an innovation-nourishing market structure, characterized by the prevention of arbitrary government interventions and vigorous oligopolistic

[8] In February 2006 China's State Council issued the "Complementary Policies" (CP) to support the implementation of IIS. The CP specifies that the government will support the strategy of building an innovative country by actions in ten areas, including investment; tax preference; finance; government procurement; the route of introduction-assimilation-innovation; creation and protection of intellectual property rights; management of talent; education; and building research bases for innovation and management.

competition, only began to emerge and develop in free-market economies[9] within the last two hundred years or so.

Our conceptual model hence stems from the aggregation of Baumol's interpretation with the research methodology we proposed in section 3.1 (see Figure 1). In a certain industry, the bulk of private R&D spending is shown to be conducted by a very small number of very large firms, which are forced to internalize innovative activities rather than leave them to fortuitous discoveries and thus turn them into a routinized, assembly-line process; small entrepreneurial entrants (independent innovators) continue to predominate in revolutionary breakthroughs with large oligopolists providing streams of incremental improvements that add up to major contributions; moreover, enabled by the intellectual property mechanism, these firms voluntarily disseminate much of their innovative technology widely and rapidly, both as a major revenue source and in exchange for the complementary technological property of other firms, including direct competitors, which helps to internalize the externalities of innovation and speeds up the elimination of obsolete technology.

[Insert Figure 1 Here]

In general, this model maintains that, as long as there is no administratively created entry barriers, as long as misguided anti-trust bureaucrats avoid frustrating the legislation, and, as long as the incentives in the system do not distort the allocation of resources from creative innovation to parasitical rent-seekers, the three market structure features referred to above can do – and actually have already done – a far better job at generating technological progress than any other economic regime[10].

Before we come to the anatomy of China's technology catch-up attempt, in particular, the latest IIS, on the basis of the preceding model there are several observations to be made that deserve more attention:

I. The critical and growing role of routine innovative activity does not mean that independent innovation no longer plays a significant role. On the contrary, "The most revolutionary new ideas have been, and are likely to continue to be, provided preponderantly by independent innovators" (Baumol, 2002b). Therefore, the threshold of market entry may be increased by sunk costs, rather than by administrative monopoly or oligopolistic collusion, which artificially discourages independent innovation.

II. Only by imposing the constraint of competition can people establish the correlation between R&D outlays and innovation, or between oligopolists and routinized innovation. In this way, the existence of a payoff structure and a level playing field favoring "productive entrepreneurship" (Baumol, 1990, 1993) become irreplaceable identification mechanisms for efficient R&D and fruitful oligopoly.

III. Technology licensing from independent innovators to oligopolists and among oligopolists is partly made possible by assuming that the oligopolists prefer staying on the technology frontier rather than importing matured technology as a follower. Yet this is seldom the case, while technology leaders are not allowed to threaten the profit

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[9] A discussion on controversies about the dichotomy between "free market" system and "all others" can be found in Mokyr (2002).

[10] Recent evidence on the robustness of this model can be found in empirical work by Aghion et al. (2005) and associated operational models.

of their followers.

3.3 Inferences and Hypotheses of Our Study

China's market structure for innovation production can no longer regress to a command-economy pattern as a result of the painful lessons learned from the failure of its second catch-up(1952-1978). Apparently, there is only one desirable model currently available to pursue—the free market economy, which if approached properly, has lately been proved to be feasible as evidenced by the successful experiences of Japan, Taiwan, Hongkong, Singapore and S. Korea. After the mid-1990s, China's assertion to be a market economy and its final accession into the World Trade Organization (WTO) additionally reflected its determination to release and upgrade the country's comparative advantage by embracing competition between market economies. This in general explains why we choose the Baumol model to infer the outcome of China's innovation strategy as a criterion.

But we should not forget that this market economy was defined as a "Socialist Market Economy" (SME). In other words, the CPC's political oligarchy should not be put danger on the journey to a market economy. Therefore, the state economy must maintain predominance in the "strategic" and "pillar" industries (J. Hu, 2007). Further, it must generate sufficient tax revenues to ensure the central government's authority over other vested interests and local government, whose exploding socioeconomic power tends to result in regionalism and subvert the political and economic order (Parker, 1995; Young, 2000).

As a consequence, the market structure in China is imposed with a political and ideological requirement concerning the performance of SOEs. Government interventions thus can never be avoided as long as the level playing field allows wash-out. Most studies so far have been wrestling with this dilemma, and tend to condemn China's political system, which is apparently problematic yet is unlikely to change in the near future.

Logically, there are two ways out of this dilemma, assuming the maintenance of the CPC's political position: first, by making the SOEs competitive with the non-state sector in all potentially contestable markets, which means that the SOEs, as a winner of fair play, will not be washed out; second, by allowing SOEs to be protected in selected industries by administrative monopoly/ oligopoly, meaning that SOEs are mandated to be the winner. The first way seems to be a perfect solution, yet too perfect to be carried out from the perspective of modern firm theory (Bai and Xu, 2005; Parker, 1995) and with no successful precedent to follow; the latter, conversely, falls back into the vicious circle of SOEs in a centrally planned economy and is doomed to fail in a long run. Therefore, in practice, only one option is left for the Chinese government—challenging extant theories such as "principal-agent" and "soft budget constraint" with an innovative reform of SOEs' corporate governance, transforming them into competitive oligopolists which can survive without administrative protection.

But is it possible to cultivate technological competitiveness in a noncompetitive environment?

Discouraged routinized innovation. In October 2006, almost coincident with the promotion of IIS in China's "11^{th} Five Year Plan", SASAC declared outright that seven sectors (Table 1), on account of their strategic importance related to national or economic security, would maintain their government controlled status, through either sole ownership or an absolute controlling stake. Furthermore, the state will also stick to its absolute or relative controlling stakes in other industries, described as pillar and basic industries (SASAC, 2006). While defining strategic sectors is a fairly common practice among other governments, imposing restrictions on the "basic and pillar industries", which includes the auto, construction and IT sectors where government ownership normally plays a minor role, definitely exceeds the current practice in industrialized economies. As we have stressed in observation ***II***, competition is the first prerequisite and an irreplaceable impetus to enable the operation of the "free market innovation machine". The administrative monopoly or nominal oligopoly in China, however, fundamentally removes the incentive for innovation—as long as the market entry of competitors such as domestic private enterprises or MNCs is prohibited, the life-and-death matter for SOE managers to fulfill their imposed multitasks will still be the continuity and stability of production within their prefectures (Bai and Xu, 2005). In that case, the opportunity costs of risky R&D outlays on innovation appear to be unfavorable compared with the investment in importing matured technology bundles, especially when there is no need for SOEs to worry that their foreign licensors may use their technology dependence against them someday. Meanwhile, enormous R&D outlays on rountinized innovation also compete with the SOE managers' budget for lobbying key officials from SASAC or even higher levels in order to obtain and extend their "exceptional" treatment: monopoly position, special access to resources, exemption from environmental protection or energy-saving rules and regulations, which will reduce the risk of "particularism", the biggest risk for monopolists and oligopolists in China's state-protected sectors. In this regard, the technology risk of being a parasite on imported equipment is relatively minor.

[Insert Table 1 Here]

As a matter of fact, the central government in China is certainly aware of the drawbacks of the SOEs' monopoly in terms of their inherent inertia to innovation. In response, SASAC mandated a hardened R&D investment index to complement traditional fiscal standards for assessing the overall performance of SOE managers[11]. Accordingly, the central SOEs' R&D investment reached a level of $9.6 billion in 2004, a 76 percent and a 218 percent increase on the figures for 2003 and 2002, respectively; and triadic patents (issued by the US, the EU and Japan) and domestic patents issued to central SOEs have increased at an average annual rate of 28 percent since 2004. In 2005, the ratio of central SOEs' R&D investment to their sales climbed

[11] Before the promulgation of IIS, SASAC possessed three major functions: promoting SOE reform, state-owned economy redistribution and increasing state-owned assets. After April 2006, the central government designated the promotion of SOEs' innovation as SASAC's fourth function. Accordingly, SASAC has appended a new index of "science and technology investment" to assess senior managers' performance in SOEs after 2006. However, profit and net yield of asset, will still be the basic indexes used to asses senior SOE managers (Xinhua,2006).

up to 1.5 percent, and the industrial SOEs' percentage was 2 percent (SASAC, 2006). Hence, the Chinese government was convinced that monopolists or oligopolists in China could also be able to play a leading role in empowering innovation production. For instance, among 14 key research projects designated by the nation's 11th Five Year Plan, 12 are allocated to the central SOEs.

However, this government-mandated R&D investment wave is problematic for, at least two reasons: first, as warned in observation ***II***, R&D outlays tend to suffer from low efficiency and usually result in waste when they are isolated from the identification mechanism composed of competition and entrepreneurial commercialization. The setup and enlargement of R&D departments in SOEs, together with the proposal of research projects, are designed to make them become specialists in overoptimistic grant applications, or, even worse, deliberate frauds to bid for government grants (Barboza, 2006). Without the test of competition, research resources among SOEs and public research institutes are seriously segmented or repetitive. It has recently become known that merely less than 10 percent of China's medium- and large-size firms' R&D achievements could be applied at the industrial level (Zheng and Chen, 2007), revealing the astonishing inefficiency of their R&D investment.

Second, while increased R&D investments of poor efficacy can not justify their outlay by making profit, they become heavy burdens on SOEs. SASAC announced in 2006 that, within 5 years, the ratio of central SOEs' R&D investment to their sales has to reach 3.5 percent from 2 percent while technological reserves should increase to 15 years at least. This is not a rigorous requirement[12], but it is a difficult one under the current situation where most SOEs have to import technologies for their present needs. Moreover, the spending by China's industrial enterprises on technology indigenization is only 6 percent of that of technology import, while this ratio in S. Korea and Japan reaches 500 percent to 800 percent. However, SASAC outrageously regulated that independently developed new products should account for at least 30 percent of the central SOEs' total products by the end of 2011. Such a radical transformation would be almost a "big bang" or another "Great Leap Forward", given the SOEs' current technology development model. But what if these ambitious objectives established by unprofessional government officials are far beyond the real capability of SOEs? Rents will be generated in supervising and inspecting organizations such as SASAC, while SOE managers will have to manipulate statistics and achievements. Finally, new policies will induce new rent-seeking opportunities.

Hindered Independent Innovation. The independent innovations in Baumol's theory: namely, those scattered innovations conducted by small entrepreneurial enterprises, ironically face a dead-end during the implementation of IIS in those monopolistic industries. First, recalling observation ***I***, while the Chinese government can not afford "creative destruction" where private entrants may replace state-owned incumbents with revolutionary technology breakthroughs, any persons of entrepreneurial genius will be immediately paralyzed by the thought that their efforts

[12]The R&D-sales ratio is still relatively low compared with the normal industrialized countries' ratio of 5 percent. Furthermore, most giant MNCs have a 30-year to 50-year technological reserve (Zheng and Chen, 2007).

will only win them punishment or confiscation rather than rewards. More tragically, 7 out of 11 priority areas identified by the S&T Guideline appear to overlap with those key industries or pillar industries defined by the SASAC (see the Appendix), suggesting that, in those intersections, there will be no promising futures for independent innovators. Therefore, after one step forward in IIS, state monopoly again has the effect of driving talent away.

Dissemination Without Outlets. Depending on prices, sunk costs and opportunity costs, it is often most profitable for the monopoly owner of an innovation to specialize in the business of renting the input to others, rather than using it itself as an input to its own final product. Sometimes, the highest profits are obtained by the owner of the rights to an innovation, if it simultaneously uses the invention as an input in its own production and rents its use to others. Unfortunately, as shown by observation ***III***, when monopolists or administratively segmented oligopolists are discouraged from participating in innovation and are reconciled to more matured, imported technology bundles which hardly require the effort of indigenization, the outlets for technology dissemination also shrink: independent innovators who prefer to become specialized licensors have to abandon their ideas, since there is less demand from the incumbents to commercialize their products and to put them into large scale production because of their limited indigenization capability bred by technology dependence. Meanwhile, Chinese monopolists generally avoid technology collaboration or trading within their industry, especially if such a collaboration or trading crosses regional or bureaucratic boundaries, simply because these practices would generate too much transaction costs and political risk during the entanglements with other SOEs and their patrons from associated government ministries. Although the establishment of SASAC is assumed to overcome such deficiencies of departmentalization, several recent cases have proved that even SASAC itself can not be exempted from the tyranny of powerful patrons behind certain SOEs (Naughton, 2008).

In sum, by applying our conceptual model in the Chinese industrial context, we conjecture that the prospects for IIS and its preceding technology catch-up attempt appears to be seriously obscured as a result of the counteractive effects caused by administrative monopoly or oligopoly. As shown in Figure 2, our specific hypotheses suggest that a market structure which prevents competition in a wide range of selective industries tends to breed, at the conduct level, an inherent R&D inertia among SOEs. Accordingly, it restrains entrepreneurial entrants and reduces the demand for technology dissemination. As a consequence, at the performance level, while the technology catch-up efforts measured by some input-oriented indicators may improve, the actual technology gap between SOEs and their comparable rivals will rather increase.

[Insert Figure 2 Here]

4. Empirical Evidence

4.1 R&D Inertia

It is yet too early to directly deny the validity of IIS with any available data set, simply because the time span after the promulgation of the strategy, merely two years, is too short for the entire policy sets to unfold in this large country, let alone to take effect. However, in essence, IIS is merely an aggregated extension of the Chinese government's consistent strategy of striving for the technology catch-up (Sutherland, 2007; Yao, 2006; Zheng and Chen, 2006, 2007), i.e. by increasing overall R&D investment and obliging SOEs, especially the central SOEs, to play a vital role in building an innovative country while permitting them state monopoly or oligopoly. Such consistency, to some extent, allows us to test this paper's preceding hypotheses preliminarily by carefully examining some associated historical empirics.

Our first hypothesis at the conduct level in Figure 2: namely, the existence of R&D inertia in Chinese industries, contradicts some conventional empirics at first glance, as shown in Figure 3, where conventional indicators adopted to measure a country's efforts in innovation (i.e. gross expenditure on R&D (GERD) and its intensity as a percentage of GDP) seem to echo Jefferson's prediction in 2005 that China has been experiencing an S&T takeoff since the mid-1990s. In addition, Figures 4 and 5 show an increasing and dominant share of industry-performed and -financed R&D outlays, which indicates favorably that the market is allocating most of the R&D resources, while enterprises have been more attracted to technology innovation.

[Insert Figure 3- Figure 5 Here]

However, Du et al. (2006) admitted that the NBS's adjustment of the statistical scope regarding R&D resources since 2000 had significantly increased the contribution of the industry sector. Sourcing back to Shi (2004), we noticed that NBS after 1999 started to incorporate R&D expenditure from small high-tech firms located in national level high-tech development zones (HTDZs). This was further extended in 2000 to include small high-tech firms outside HTDZs, FFE sponsored independent research institutes, and firms specialized in software development, geological exploration, water conservancy, and general technology services. Shi also estimated that previous adjustments had resulted in an R&D expenditure rise that amounted to 12.6 billion RMB, 0.14 percent of China's nominal GDP in 2000. With this reference, we have executed a recalculation showing that this "bonus" part accounts for 25.60 percent of the contemporary R&D expenditures financed by the industry sector in 2000. Therefore, a 41.12 percent share in GERD financed by the industry sector was increased to 55.24 percent under the new statistical scope, which means that compared with the 34.94 percent share in 1999, nearly 70 percent of the increased portion can be explained by the application of the new statistical definition. Likewise, similar effects undoubtedly exist with respect to both the GERD performers' statistics and the GERD statistics.

Therefore, our further investigations on the data sources suggest that the conflicts between hypothesized R&D inertia and the empirical data are magnified primarily as a result of the adjustments that took place in China's official statistical orientation. In other words, the Chinese government's policy effects after the mid-1990s, in terms of encouraging R&D investment, should first be deflated to a moderate degree, rather than be exaggerated into an S&T takeoff.

More importantly, Table 2 reveals that the hypothesis of R&D inertia evidently prevailed at least between 2000 and 2004, where the FFEs' R&D expenditure growth rate (27.60 percent) was 11.20 percent higher than that of the domestic enterprises (DEs); and the R&D intensity gap between FFEs and DEs expanded from 0.39 percent to 1.01 percent. This tells us that, even without taking account of the efficiency issue, the R&D investment increase rate of DEs was comparatively falling behind that of their competitors in the domestic market, despite their loudly proclaimed tendency to grow in an absolute terms.

[Insert Table 2 Here]

As was further uncovered by Figure 6, the Chinese government's decision to increase its S&T investment surprisingly resulted in a decreasing percentage of S&T expenditure in government revenue. If, however, the government really does prefer a technology catch-up, the S&T expenditure share in total government revenue is rather assumed to increase, although the government's share in total S&T expenditure may decrease because of the rise in the industry sectors. This means that the R&D inertia even prevails in the government sector, while the money promised for innovation is diverted to other places[13](Wei, 2008).

[Insert Figure 6 Here]

4.2 Expanded Technology Gap

General trade theory indicates that the upgrading of a nation's comparative advantage and industrial structure can be best reflected by variations in its export composition, particularly in terms of the contribution from advanced industrial exports or high-tech industries (Gilboy, 2004; OECD, 2002). Jefferson (2005) once made the criticism that it was inappropriate to evaluate China's improvement in innovation capacity largely according to its high-tech export sector. Since this sector accounted for barely 14 percent of the national merchandise exports in 2000, "the story of China's technological transformation is far more subtle than the development and export of high-tech goods". But, no matter how subtle the story is, the

[13] The latest statistics on China's fiscal revenue announced by the Ministry of Finance (MOF) in March 2008 showed that the state's fiscal revenue in 2007 hit 5.13 trillion RMB ($733 billion), an increase of 32.4 percent year-on-year. This is 20.7 percent of the nation's GDP. After taking account of the additional income from government debt issuance (2 trillion RMB in 2007), extra-budgetary items and local governments' administrative fees, the actual government revenue has soared to 11 trillion RMB, or 44 percent of the national GDP, which approximately equals the fiscal revenue ratio in 1978 (Xinhua,2008). Meanwhile, government expenditures in the public service area, such as social security, education and public health, repeat the pattern we discovered for R&D expenditure. Criticism has thus arisen implying that the Chinese government is devouring the country's fortune (Wei, 2008).

improvement of China’s innovation competitiveness has to be tested on a level playing field — that of international trade competition, where an increasing share of high-tech products in total exports should be taken as the most direct indicator. Therefore, the performance of China’s domestic firms measured by this indicator undoubtedly reflects its own technological competitiveness in comparison with their FFE rivals. In addition, the proportion of high-tech goods in China’s exported merchandise more than doubled to 29 percent in 2006, which further limits the validity of Jefferson’s criticism.

In Figure 7, we observed that the dominance of foreign firms in China’s high-tech products[14] exports was unexpectedly reinforced, despite favorable reports simply using conventional, input-oriented indicators. The share of those high-tech exports produced by FFEs grew from 73.78 percent to 89.21 percent during the past decade or so, indicating that China’s soaring high-tech exports in the same period were attributed more to FFEs’ enlarged production capacity and enhanced technology level, rather than their domestic counterparts. What is more frustrating, a comparison of the market share of SOEs and FFEs in terms of high-tech products exports reveals that both the increased R&D expenditures of the SOEs and the government’s monopoly policies in selected high-tech industries (e.g. the aviation and aircrafts manufacturing industry, and the medical treatment instrument and meter industry) have failed to enable a SOE technology catch-up. This is consistent with our second hypothesis at the performance level in Figure 2 that, even though administrative command or mandated performance measurements may force DEs, particularly SOEs, to increase their R&D investment, the efficacy of such a marginal increase is often low, and ultimately results in an increased technology gap between SOEs and FFEs.

[Insert Figure 7 Here]

5. Concluding Remarks

It is clear that China has to become innovative to sustain its growth, and the tactics to achieve this is nothing less than the encouragement of competition in a free market economy. However, this paper shows that the ambivalence about competition which stems from the government’s concern to maintain political oligarchy will hamper its parallel efforts aiming to build an innovative country. If such is the case, does that mean that policy instruments such as IIS are merely bravado, and that the prospects for China’s technology ascendance is only a “phantom”?

This is not, however, entirely true. As we will see, “China is still a nation searching for a country”(Boisot and Child, 1996). In contrast to the Western democratic model, where a positive cohesion between government and society tends to exist, with the state merely being the codification of the nation through the rule of law, the Chinese model has yet to successfully codify a nation that has been accustomed to conduct transactions according to customary uncodified norms.

[14]The NBS defines the high-tech industries as Medical and Pharmaceutical Products, Aviation and Aircrafts Manufacturing, Electron and Communicate Equipments, Electronic Computers and Office Equipments, and Medical Treatment Instrument and Meter(NBS,2007b).

Establishing the notion of the criticality of innovation in such a huge and populous country, historically dominated by its preceding culture-history context, can not be realized in a short time. And neither can state patronage in industrial governance be ruled out in the near future. Hopefully, the promulgation of IIS will now at least enable the country to edge toward an incremental codification of the rules and institutions for innovation, albeit without the promise of an immediate takeoff.

Two other factors may also support prudent optimism. Foremost, some of the market entry restrictive measures are to be phased out gradually as part of China's WTO accession commitments. This will prevent the Chinese government from slowing down its SOEs' reform and associated political reform if necessary, so as to ensure the competitiveness of the whole economy's and thus guarantee its legitimacy. Second, in those competitive sectors that were to some extent exempted from severe government intervention, though less technology intensive, more vigorous innovations can be expected through persistent competition, comparative advantage upgrading, and the implementation of IIS. Their upcoming bottlenecks in terms of technology catch-up caused by the backwardness of those monopolized industries will become a domestic "push" to annul prolonged government protection.

In sum, 30 years after its reform and open-door policy, China is still seeking access to an express road for technology catch-up. Ambitious plans, e.g. IIS, are continually undermined by deep-seated structural and institutional issues such as state monopoly. The exploration of the solution to this conundrum can be likened to the life-stages described by Confucius as moving from "I stood firm" to "I had no doubt", except that China's road toward independent innovation is likely to be a long struggle rather than the work of just another 10 years.

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Table 1 SASAC's regulation on SOEs' position in various industries

Official definition	**Specific industries**	**Ownership requirements**	**Central SOEs**
Strategic and key industries	Defense, oil & petro-chemicals, power generation, telecom, coal, civil aviation, shipping.	Solely state-owned or absolute state control; increase state-owned asset accordingly.	40
Basic and pillar industries	Equipment machinery, auto, IT, construction, steel, chemicals, land & mining exploration, base metals, R&D.	Absolute or conditionally relative controlling stake; enhance the influence of state ownership even though the ownership share is reduced if appropriate.	70
Other industries	Trading, investment, agriculture, pharmaceutical, construction materials, geological exploration.	Maintaining necessary influence by controlling stakes in leading companies; in non-key companies state ownership will be clearly reduced	50

Source: Mattlin (2007).

Table 2 Comparison of R&D expenditure and intensity by enterprise ownership (2000, 2004)

	2000			2004			
	R&D Expenditure (100 million RMB)	Ratio (%)	R&D Intensity (%)	R&D Expenditure (100 million RMB)	Ratio (%)	R&D Intensity (%)	Growth Rate: 2000-2004 (%)
DEs	389.50	79.50	2.98	805.00	72.90	3.50	16.40
FFEs	100.20	20.50	3.37	299.50	27.10	4.51	27.60
FFs	59.40	12.10	3.52	210.50	19.10	4.79	33.20
HMT	40.80	8.30	3.17	89.00	8.10	3.95	18.00
Total	489.70	100.00	3.05	1104.5	100.00	3.73	18.90

Source: China Science and Technology Statistics (STS) (2007).

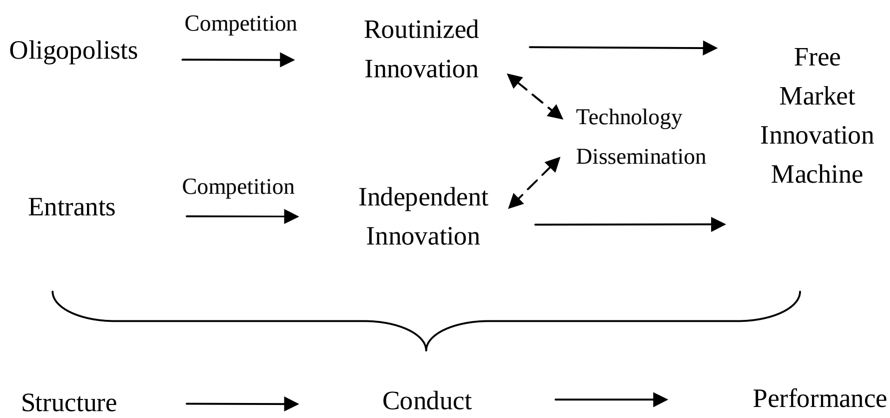

Figure 1 A conceptual model of industrial competition toward innovation
Sources: Baumol (2002a; 2002b; 2004).

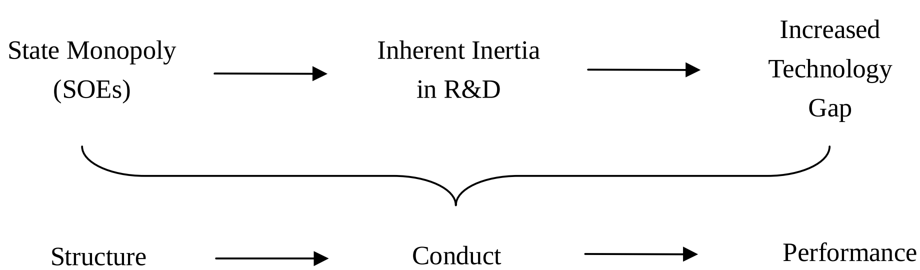

Figure 2 Hypotheses of the conceptual model in the Chinese context

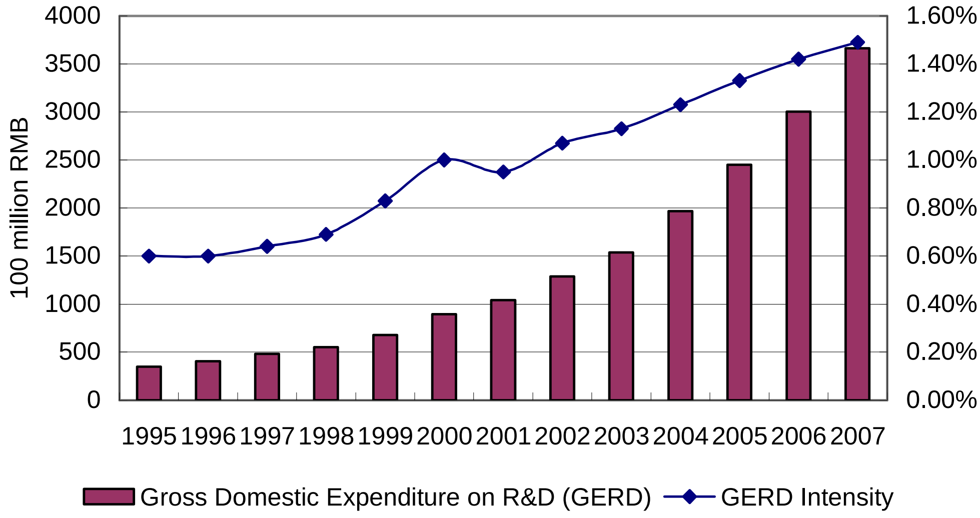

Figure 3 GERD and GERD intensity as a percentage of GDP in China, 1995-2007

Source: National Bureau of Statistics of China, NBS (2007c; 2007d; 2007e; 2008).

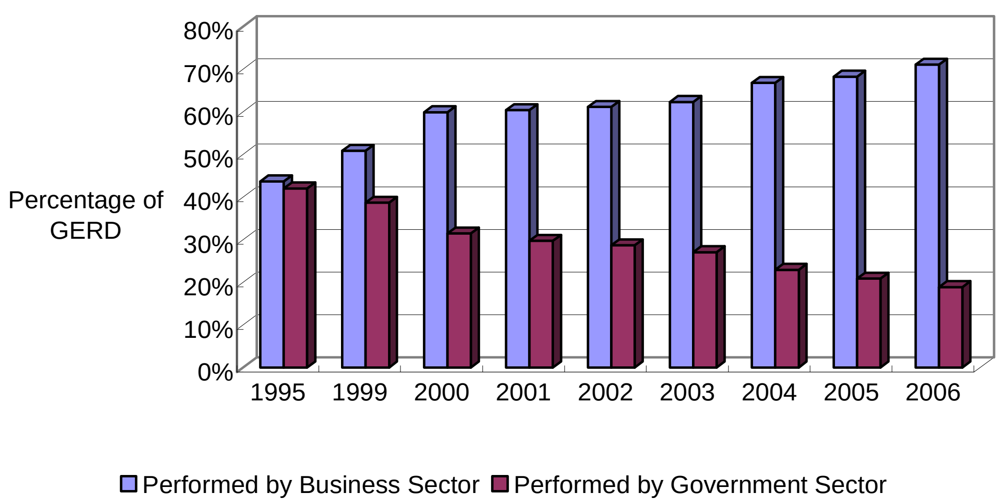

Figure 4 GERD ratios of the Business and Government sectors, 1995-2006

Sources: NBS (2007d) and OECD (2006).

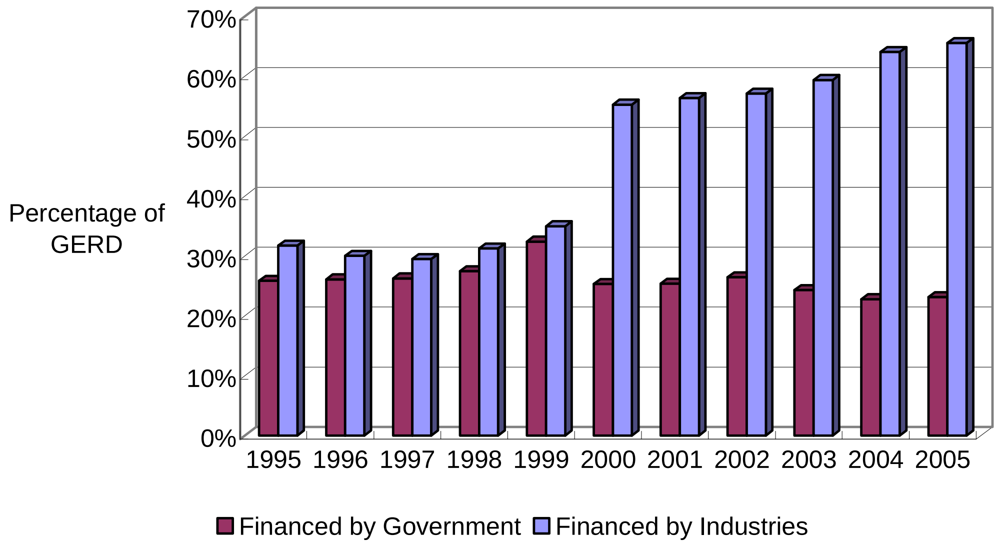

Figure 5 GERD ratios financed by Industries and Government, 1995-2005

Source: NBS (2007a).

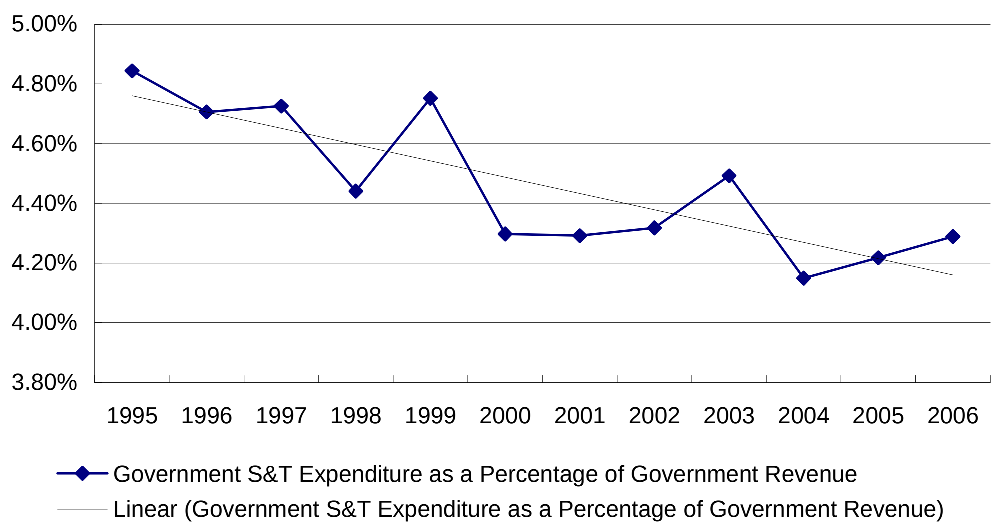

Figure 6 Government expenditures on S&T in total Government revenue, 1995-2006

Source: NBS (2007c).

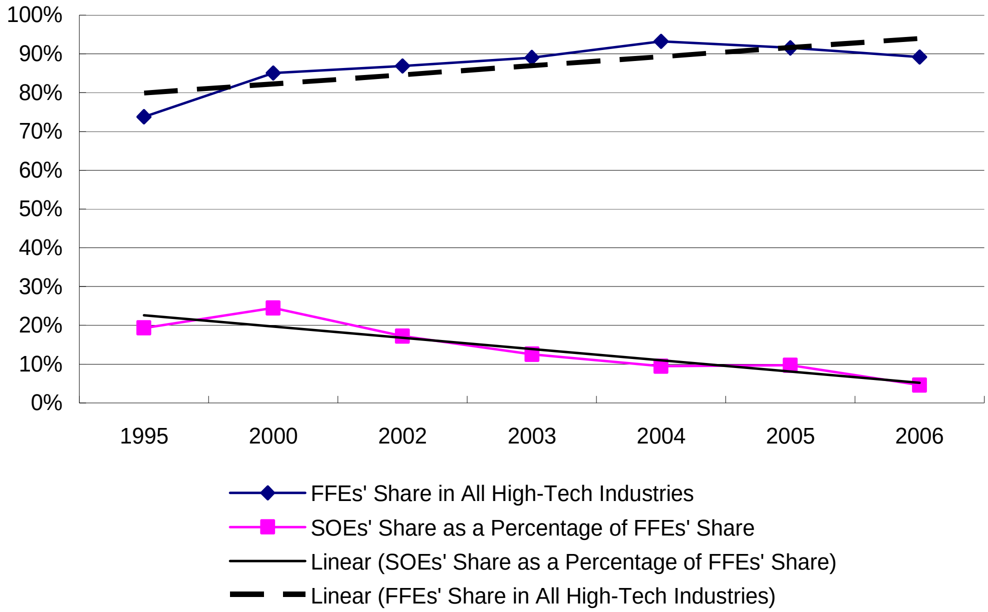

Figure 7 FFEs' share in national high-tech products export and a comparison of SOEs and FFEs in high-tech products export (selected years from 1995-2006)

Source: NBS (2007b).

Appendix

Highlights of China's S&T Guideline

A. Eleven Priority sectors:

(1) Energy*
(2) Water and mine resources*
(3) Environment
(4) Agriculture
(5) Equipment Manufacture*
(6) Transport*
(7) Information industry and modern services industry*
(8) Population and health care
(9) Urbanization and urban development;
(10) Public security*
(11) National defense*

* Denotes that this sector is regulated by SASAC to be predominated by SOEs.

B. Eight Technology Areas:

(1) Biotechnology
(2) Information technology
(3) New materials technology
(4) Advanced manufacturing technology
(5) Advanced energy technology
(6) Oceanic technology
(7) Laser technology
(8) Space technology